STRATIGRAPHIC NOTES ON LOWER CAMBRIAN FOSSILIFEROUS META-SEDIMENTS BETWEEN CAMPBELL CREEK AND TUNKALILLA BEACH IN THE TYPE SECTION OF THE KANMANTOO GROUP, FLEURIEU PENINSULA, SOUTH AUSTRALIA

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Summary

Hyolithids and other Lower Cambrian fossils occur within marbles in low-stage metamorphic rocks (Forktree Limestone and Heatherdale Shale) forming the core of a north-east plunging regional anticline, overturned to the south-east. A great thickness of partially bioturbated Kanmantoo Group metasediments, dominantly clastics, but including sulphide-rich calc-phyllites of the Talisker Calc-siltstone, conformably overlie the Heatherdale Shale.

The rapidly deposited clastics, including numerous thin conglomerates, are interpreted as products of the Kangarooian Movements known to have affected the region now occupied by Investigator Strait and Gulf St. Vincent.

The newly proposed stratigraphic subdivision for that part of the Group discussed should lead to a more reliable picture of the occurrence and the relationships of these rocks to other sequences within the Mt. Lofty Ranges and Kangaroo Island.

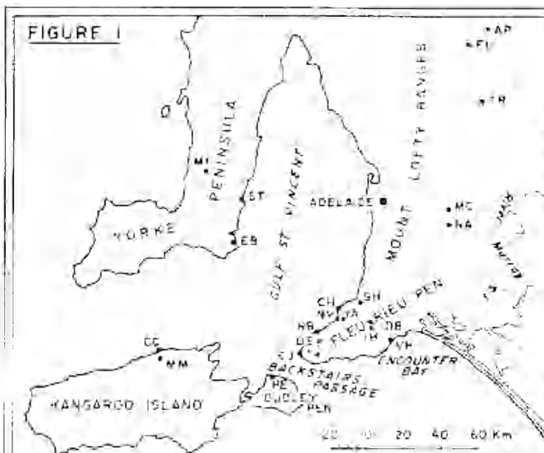
Introduction

The Fleurieu Peninsula south of Adelaide, South Australia, holds the key to the age relationships of the metasedimentary rocks constituting the Kanmantoo Group. This vast sequence crops out in an arcuate belt extending from Australia Plains, north-east of Eudunda in the eastern Mt. Lofty Ranges, through Fleurieu Peninsula and across large sections of Kangaroo Island (Fig. 1). Sprigg and Campana (1953, p. 14) defined its type locality as "the section observable along the south coast of Fleurieu Peninsula, between Campbell Creek and Rosetta Head, Victor Harbour, where the formations are well exposed and very characteristic".

The present paper gives the results of our investigations of the geology of the lower part of the Kanmantoo Group, beautifully exposed along the rugged southern coastline of Fleurieu Peninsula between Campbell Creek and the western extremity of Tunkalilla Beach[1]. It is anticipated that subsequent papers will:

(a) complete the stratigraphic scheme for the Kanmantoo Group within its type area;

FIGURE 1



GEOGRAPHICAL LOCALITY MAP

LEGEND

AP	AUSTRALIA PLAINS	MM	MOUNT McDONNELL
CC	CAPE CASSINI	NA	NAIRNE
CJ	CAPE JERVIS	NV	NORMANVILLE
CH	CARRICKALINGA HEAD	PE	PENNESHAW
DE	DELAMERE	RB	RAPID BAY
DB	DEVIL'S BACKBONE	SH	SELL CK HILL
EB	EDITHBURGH	ST	STANSBURY
EL	EUDUNDA	—	TALISKER MINE
IH	INMAN HILL	TR	TRURO
MI	MINLATON	VH	VICTOR HARBOUR
MC	MOUNT CHARLES	YA	YANKALILLA

[1] Where possible, our traverse was along the base of the cliffs. Certain stretches, never more than 200 metres in length, were impossible to negotiate and in these cases we were forced to collect data along the top of the cliff.

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(b) test the newly devised scheme by applying the results to the geology of the Dudley Peninsula, Kangaroo Island;

(c) present the results of a remapping programme for part of Fleurieu Peninsula;

(d) comment on the progressive metamorphism of certain key stratigraphic horizons from the chlorite, through the biotite and into the andalusite grades of metamorphism; and

(e) discuss preliminary rubidium-strontium geochronological data for the Kanmantoo Group.

PROBLEMS OF THE AGE AND RELATIONSHIPS OF THE KANMANTOO GROUP

Opinions regarding the age of the Kanmantoo Group metasedimentary rocks have varied. Rocks now known to belong to the group were originally described by Woolnough (1908) as part of the Barossa series of Precambrian age. The first hint of their true age was given by Madigan (1925) who, from an examination of the coastline between Sellick Hill and Victor Harbour, argued with some reservations that *all* the pre-Permian rocks of Fleurieu Peninsula south of Yankalilla valley were likely to be Cambrian in age.

The earliest mention of the Kanmantoo Group (*actually Kanmantoo Series*) was by Sprigg, Whittle and Campana (1951) in the legend of the Adelaide 1:63,360 sheet. This showed the "series" occurring east of the Nairne Fault, which separated it from rocks belonging to the Proterozoic Era (Adelaide System), Torrensian, Sturtian and Marinoan Series [or using the style of nomenclature of Daily (1963), the Late Precambrian (Adelaide Supergroup), Torrens, Sturt and Marino Groups respectively]. Its age was shown as "? Early Palaeozoic Era".

In addition to defining its type area, Sprigg and Campana (1953, p. 13) pointed out that the Kanmantoo Group follows above "a limited band of '(?) algal structured' marble" and the "(?) coprolitic phyllite slates four miles southeast of Cape Jervis". Our mapping substantiates these observations, and shows that the Kanmantoo Group conformably overlies metamorphosed beds which we correlate with the Forktree Limestone and Heatherdale Shale of Abele & McGowran (1959), the type area for which is in the northern part of Fleurieu Peninsula. The age of the lower part of the group is therefore considered to be Lower Cambrian. Sprigg and Campana (1953) suggested that the group may extend into the Ordovician.

From their mapping of the Echunga 1:63,360 sheet, Sprigg and Wilson (1954) showed that the Kanmantoo Group followed above the Macclesfield Marble which, because of its position in the sequence, was equated by Sprigg (*in* Sprigg & Campana 1953) with the Archaeocyatha-rich limestones on the western side of the Mt. Lofty Ranges. In addition, the Echunga sheet showed the main distribution of the Kanmantoo Group to be to the east of the Nairne Fault, in contact with rocks to the west ranging from the Marinoan Series up to and including the lower parts of the Kanmantoo Group. On the Gawler 1:63,360 sheet, Campana (1953) did not use the term Nairne Fault. Nevertheless, the Kanmantoo Group is shown in fault contact with the Torrensian Series west of the northern continuation of the Nairne Fault, the same relationships as drawn on the Adelaide 1:63,360 sheet.

The mapping of the Yankalilla and Jervis 1:63,360 sheets (Campana & Wilson 1954a, 1954b; Campana, Wilson & Whittle 1955) showed that contrary to Madigan's earlier interpretations, parts of Fleurieu Peninsula contained areas of metasedimentary rocks and intrusives referred to the Archaean Era, the Adelaide System, and Cambrian as high as the phosphate-rich Heatherdale Shale. All these formations were older than the Kanmantoo Group as defined by Sprigg & Campana. Subsequent re-mapping by Thomson and Horwitz (1962) largely substantiated these conclusions. However, Daily (1963) showed that the regional structure between Rapid Bay and Delamere as portrayed on the Jervis 1:63,360 and Barker 1:250,000 sheets was incorrect, and that large areas mapped as Kanmantoo Group belonged to the Sturt and Marino Groups. Further, the discovery of Lower Cambrian fossils above the Marino Group in both the Mount Terrible Formation and Sellick Hill Limestone (metamorphosed phase) confirmed the Lower Cambrian age of the Delamere marbles, and proved conclusively that the Kanmantoo Group in the Delamere region *conformably* overlies the Heatherdale Shale (phyllite phase), and that its basal formation is the Carrickalinga Head Formation (metamorphosed phase) and likewise Lower Cambrian in age.

Earlier, several publications had already dismissed the concept of the Nairne Fault. Campana & Horwitz (1956) were the earliest to do this when they postulated that the Kanmantoo Group was transgressive across rocks varying in age from Archaean to the Lower Cambrian Heatherdale Shale (phyllite phase). Daily (1956) accepted this unconformity hypothesis (but see below). However, Horwitz, Thomson & Webb (1959), Horwitz (1960), Horwitz & Thomson (1960) and Thomson & Horwitz (1961) argued that not only was the Kanmantoo Group transgressive, but that the earliest Cambrian represented by the basal arkose of the Mount Terrible Formation was also transgressive across folded Adelaide System rocks in the Sellick Hill area. We are in agreement with the transgressive nature of the Mount Terrible Formation (Daily 1963), but we dispute the transgressive character of the Kanmantoo Group as well as many of the stratigraphic correlations made by Horwitz, Thomson & Webb (1959) involving metamorphic and unfossiliferous rocks on the eastern side of the Mt. Lofty Ranges, which they referred to under the term "basal Cambrian". (Under present stratigraphic nomenclature, this would embrace rocks of Lower Cambrian age from the base of the Mount Terrible Formation to the top of the Heatherdale Shale.) For example, there is already evidence in hand indicating that many occurrences of their "basal Cambrian" involve rocks of Late Precambrian age. Moreover, we note that Thomson *in* Parkin (1969, p. 103) now doubts the validity of the "basal Cambrian" age of the Macclesfield and Mount Barker Quartzites and believes that they "are also probably members of the Strangway Hill Formation". In addition, we note that the phosphatic slate regarded by Horwitz, Thomson & Webb (1959) as the equivalent of the Heatherdale Shale, is shown in their stratigraphic succession above the Macclesfield and Mount Barker Quartzites.

We are of the opinion that the main bulk of the Kanmantoo Group in the eastern Mt. Lofty Ranges is in fault contact with rocks ranging from the Barossa Complex to the Heatherdale Shale, and we do not believe that the group is transgressive as postulated by Campana & Horwitz (1956) and Horwitz, Thomson & Webb (1959). We think that when key areas which we are now re-investigating have been re-mapped, faulting will be shown to have played a prominent role in the distribution of Kanmantoo Group rocks not only in the Mt. Lofty Ranges and Fleurieu Peninsula, but also for Kangaroo Island. In support of this we cite three examples:

1. Thomson *in* Parkin (1969, p. 102) regards the Kanmantoo Group as resting unconformably on Barossa Complex rocks south-east of Yankalilla Hill. However, this contact is quite clearly a fault contact[2].
2. The Kanmantoo Group as mapped by Coats & Thomson (1959) on the Truro 1:63,360 sheet almost certainly occupies a graben structure. As mapped, its contact with the Lower Cambrian metamorphic rocks about 2 km south of Truro is best regarded as a fault contact.
3. Along the Devil's Backbone, almost 2 km north-west of Inman Hill, Horwitz & Thomson (Milang 1:63,360 sheet, 1960) show Cambrian rocks resting unconformably on Sturtian rocks[3], the latter being regarded by Forbes (1957) as basal Strangway Hill Beds. Forbes mapped a fault between his Strangway Hill Beds and the underlying Grey Spur Beds, which he regarded as resembling the Adelaide System. We agree that the fault as mapped is correct. Further, we regard the basal Strangway Hill Beds of Forbes as equivalent to the Tapley Hill Formation (phyllite phase), and the overlying "Cambrian marble" and "pyritic shales interbedded with quartzites" of Horwitz & Thomson (1960) as the Brighton Limestone (marble phase) and basal Marino Group metasediments respectively. Thus we believe that most of the type Strangway Hill Beds of Forbes does not belong to the Kanmantoo Group. Further, the mapping by Horwitz & Thomson (1960) suggests that a major fault separates the Kanmantoo Group from what we regard as Sturt and Marino Group rocks. Thus because of the uncertainty regarding both the stratigraphic position of the Strangway Hill Beds in their type area, and their relationships to rocks in the type area of the Kanmantoo Group, and in view of the fact that Strangway Hill Formation

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[2] Campana (1955) interpreted this as a fault contact. One of us (B.D.), in conjunction with the University of Adelaide Geology III class for 1964, excavated the contact to show the relationships of the Kanmantoo Group to the underlying Barossa Complex.

[3] Thomson & Horwitz (Barker 1:250,000 sheet, 1962) show "basal Cambrian" resting on Torrensian rocks instead of Sturtian rocks as in their earlier contribution.

has been used by later authors to refer specifically to the basal part of the Kanmantoo Group, we believe that the terms are best discarded. Further credence is given to this suggestion in view of the stratigraphic scheme developed in this paper for the lower part of the Kanmantoo Group within its type area along the southern coastline of Fleurieu Peninsula.

In connection with the relationships of the Kanmantoo Group in the eastern Mt. Lofty Ranges, we are reluctant to dismiss the concept of the Nairne Fault as pertaining to the Adelaide 1:63,360 sheet. Kleeman & Skinner (1959, p. 70) have pointed out that the Nairne Fault as delineated on the Echunga 1:63,360 sheet was "disproven by the mapping of marker horizons and structural features across the line of the supposed fault". The mapping of the Strathalbyn Anticline by Offler (1963) is in agreement with this statement. However, we are of the opinion that the Nairne Fault exists on the Adelaide 1:250,000 sheet (Thomson 1969) where, in the Mount Charles region, Thomson has interpreted a double unconformity bounding "basal Cambrian" rocks. We prefer to interpret the same relationships as a consequence of faulting, namely the Nairne Fault. We predict that when the structure of the eastern Mt. Lofty Ranges has been resolved, the boundary separating the younger Kanmantoo Group from mainly Precambrian rocks lying to the west will be a set of *en echelon* faults, and not an unconformity as shown on the more recent maps published by the Geological Survey of South Australia. It should be noted, however, that where Lower Cambrian rocks are overlain by Kanmantoo Group rocks without structural discordance, conformity between them can be expected.

Finally, we do not accept the proposition put forward by Kleeman and Skinner (1959) that the base of the Kanmantoo Group should be placed at the base of the "Nairne Pyritic Formation", because the base of the group as defined by Sprigg & Campana (1953) has priority, and is well below the Nairne Pyrite.

The Geology of the Type Kanmantoo Group between Campbell Creek and Tunkalilla Beach

STRATIGRAPHY

In presenting the geology of this 16 km of coastline we have been forced to abandon the term Strangway Hill Formation as discussed above, and also the term Inman Hill Formation (see Footnote 7), and to introduce a number of new stratigraphic names. The new scheme is given in Table 1 and the distribution of the stratigraphic units recognised is shown on the accompanying geological map, Fig. 2. Whilst the position of the boundaries between the formations and various members are accurately portrayed on the coastline, we must point out that we have not mapped them as far inland as the map might suggest. Their projection inland is for the sake of clarity only.

All but one of the formations are fossiliferous. The whole sequence is regarded as being Lower Cambrian in age from its fossil content, and by analogy with the Lower Cambrian sequence occurring on the north coast of Kangaroo Island (Daily 1956; Horwitz & Daily *in* Glaessner & Parkin 1958, Fig. 14; and Daily 1969).

A. Forktree Limestone (marble phase) and Heatherdale Shale (phyllite phase)

Marble and phosphatic nodular phyllites (Figs. 3–10) occupy the core of a north-easterly plunging *regional anticline* whose western limb is overturned[4]. Evidence for this overturning is given by facings from cross-bedding in the stratigraphically younger Carrickalinga Head Formation on the western limb of the fold, and also by cleavage bedding intersections and the sense of the parasitic folds on the same limb. Both the Heatherdale Shale and the Forktree Limestone can be inspected in Madigan Inlet[5] and just east thereof.

The area of outcrop of the Heatherdale Shale along the south coast is greatly exaggerated on the Jervis 1:63,360 sheet, where it is shown

[4] The regional anticline with an overturned western limb was first recognised jointly during an excursion to Madigan Inlet in 1963 by one of us (B.D.) and Dr. R. J. George, who in the same year presented a thesis towards a B.Sc.(Hons) Degree entitled "The geology of the Talisker Mine Area". We wish to record that we have consulted that work during the preparation of this paper.

[5] This geographic feature is named in recognition of the important discoveries made by the late Dr. C. T. Madigan, who first recognised and correctly interpreted the occurrence of the Delamere marble (Madigan 1925, p. 209), and later in 1939, the phosphatic nodular phyllites (see comment by Sprigg *in* Sprigg and Campana 1953) at this locality.

extending from just west of Campbell Creek to just east of Madigan Inlet. Our interpretation of the geology and structure of the same area is radically different. It also differs from that given in Thomson (1963), where failure to recognise the closure of the regional anticline at Madigan Inlet and the overturned western limb of the fold has resulted in an incorrect stratigraphic column and structure for the area. Moreover, these errors have led to unwarranted assumptions of facies changes from Cambrian carbonates at Delamere to quartz-rich clastics on the coastline. We reiterate the statement made by Daily (1963) that both Precambrian and Cambrian sequences on Fleurieu Peninsula show "remarkable constancy of facies".

The north-easterly plunge of the mottled upper member of the Forktree Limestone is visible on the extreme point on the eastern side of Madigan Inlet. On the eastern and normal limb of the fold, hyolithids and spicules of the sponge *Chancelloria* were discovered in the uppermost 2 m of the Forktree Limestone. They are visible as phosphatic steinkerns on bedding surfaces within the marble, just above a wave-cut platform. All the fossils have been deformed tectonically.

The contact between the Forktree Limestone and the lower member of the Heatherdale Shale is marked by the appearance of phyllite bands up to 8 cm thick. The almost black phyllites separate thin interbeds of dark blue-grey limestone up to 10 cm thick, and the sequence as a whole is far better bedded than the lighter coloured streaked and mottled marbles of the Forktree Limestone. Phosphatic nodules occur from the base of the member, but these are sparse. Hyolithids occur sporadically through the lower 12 m, but are abundant in a band of thin limestone about half way up the cliff face at the top of this interval. The band can be traced to the break in slope above the cliff, where fossils can be collected safely. Non-calcareous and black metasiltstones with minor impure limestone interbeds to 15 cm thick occur above the fossiliferous interval. Black phosphatic nodules elongated towards N70° at 47° are abundant from this interval onwards. Higher in the member there is a marked increase in carbonate content, resulting in a sequence of flaggy limestones with thin calc-phyllite partings. This part of the sequence is reminiscent of the topmost members of the Parara Limestone of the Billy Creek, Chace Range, and several other sections in the Flinders Ranges. (Curiously, phosphatic nodules and stringers of phosphate occur within the Parara Limestone in many areas of the Flinders Ranges.)

The calcareous beds give way to an upper member consisting of black and non-calcareous phyllites, in which the abundant phosphatic nodules plunge towards N85° at 60°. However, the phyllites do contain ovoid (*stretched*), calcareous concretions up to 1 m across and elongated in the same direction as the phosphatic nodules. Hyolithids occur sparsely in the concretions, which recall similar large concretions (also fossiliferous) occurring in the upper member of the same formation at Carrickalinga Head. The upper member contains sulphides, and their presence is readily discernible from the rusty stains seen on the surface of the rocks.

The newly discovered fossils are not in themselves diagnostic enough to fix the age of the sequence with any precision. However, identical fossils occur in the same formations in the same stratigraphic positions in the Normanville-Sellick Hill area. Recently, one of us (B.D.) has located hyolithids in the basal parts of the Heatherdale Shale along Stockyard Creek east of the Cape Jervis-Delamere road, thus realising the third predicted position "where fossils might reasonably be expected to occur in these metamorphosed rocks" (Daily 1963, p. 581).

The overturned limb of the Heatherdale Shale is notably attenuated by shearing, and inspection will show that whereas a complete sequence is found on the normal limb, parts of the formation on the overturned limb have been eliminated by faulting. Such faulting is characteristic of most of the other formations occurring on the western and overturned limb of the regional anticline, and will be alluded to below. We have not plotted a fault on the map simply because none was to be found. Nevertheless, it is quite obvious that beds present on the other limb of the very tight fold are not present on the overturned limb.

B. The Kanmantoo Group

(i) *Carrickalinga Head Formation*

A radical and fundamental change in sedimentation is ushered in at the base of the Kanmantoo Group (Figs. 8–18). There is *no* transition, and consequently the contact between its basal member, herein termed the Madigan Inlet Member, and the Heatherdale Shale is perfectly sharp. It is visible on the eastern side of the first indentation east of

Madigan Inlet, where black phyllites to metasiltstones, stained from the breakdown of sulphides, are in contact with a thin grey phyllite marking the base of the Kanmantoo Group. Black phosphatic nodules occur right up to the contact (Fig. 10). The member is characterised by phyllites (frequently bedded) alternating with more massive beds of impure metasiltstones to metasandstones. The proportion of phyllite to the coarser clastics varies within the member. For example, the thin phyllite interbeds are absent in the upper parts of the member where metasiltstones to fine grained metasandstones are dominant. Abundant small scale sedimentary structures, especially ripple phenomena, are prominent in this interval. Small north-easterly plunging folds are evident in the same beds. Characteristic of the coarser clastics are large actinolite-garnet nodules or segregations which make their appearance about 30 cm above the base of the member. These are directed towards N50° at a moderate angle. Pale grey ovoid nodules up to 2 cm across, and stringers of the same material occur in distinct layers through about 25 cm of a dark grey phyllite interbed on the overturned limb of the Madigan Inlet Member. The nodules consist predominantly of phosphate. Abundant pegmatite stringers, consisting of quartz, chlorite, muscovite, calcite and opaque mineral cut the metasedimentary rocks on both limbs of the regional anticline. Small garnet porphyroblasts are developed in the metasedimentary rocks immediately adjacent to some of the pegmatites.

The middle member of the formation, herein referred to as the Blowhole Creek Siltstone Member (phyllite phase), rests conformably on the Madigan Inlet Member. It is seen between the mouth of the first creek west of Blowhole Creek and a small inlet just east of Campana Creek[8]. The sequence consists almost entirely of pale grey laminated phyllites which are deformed into a series of minor folds plunging up to 45° towards the north-east. Where fine sand and silt interbeds occur, as in the upper parts of the member, minor sedimentary structures such as small scale current ripples and current-bedding, fossils in the form of *worm-casts,* and minor folds with steep, short and overturned western limbs are very evident. It is seen that the minor folds faithfully mimic the style of the major anticline for the region.

Pegmatite veins containing quartz, chlorite and biotite are common in the Blowhole Creek Siltstone Member. An amphibolite dyke about 3 m wide cuts the phyllite sequence, and can be inspected just west of the beach fronting Blowhole Creek. It is intersected by quartz pegmatites which indicate intrusion of the dyke prior to the final phase of metamorphism. Another amphibolite dyke, which cuts the Madigan Inlet Member, can be seen on the first point south of the contact with the top of the Heatherdale Shale.

The lower boundary of the overlying Campana Creek Member is gradational (over about 1 m) from the underlying member, and is seen in the cliff in the small inlet just east of Campana Creek. Fallen blocks indicate the change in gross lithology, and show the abundant small scale and deformed sedimentary structures to perfection (Fig. 11) in the thinly laminated beds made up of alternations of grey phyllites and paler grey metasiltstone and metasandstone layers. Many beds show bioturbation features (Fig. 12).

The section described above is to be considered as a *subsidiary type section* for the Carrickalinga Head Formation, described informally by Daily (1963) and used formally in Daily (1969). For the first time a definite upper limit can be given and its three-fold division specified. Moreover, it is now clear that the Carrickalinga Head Formation and the Mount McDonnell Formation (Daily 1969) are synonymous, the two uppermost members of the former being the metamorphic counterparts of the shales, silts and minor coarser clastics found below the Stokes Bay Sandstone along the north coast of Kangaroo Island, north-west of Mount McDonnell. Both formations are characterised by the high incidence of bioturbation within the sequence. It is proposed that the Mount McDonnell Formation be discarded as a stratigraphic term because of its identity with the Carrickalinga Head Formation.

(ii) *Backstairs Passage Formation*

A thick sequence of metasandstones overlies the Carrickalinga Head Formation and is in turn overlain by a sequence of calc-phyllites.

[8] So named to honour the significant contributions made to the understanding of the geology of the Mt. Lofty Ranges by Dr. Bruno Campana.

We propose to refer to this sandstone sequence as the Backstairs Passage Formation, named after the strait separating Fleurieu Peninsula from Kangaroo Island.

The formation boundary is drawn on the east side of a 6 m wide gulch in which no outcrop is seen. However, conformity between the two formations is assumed. From the base upwards, most of the rocks are well laminated, with grey metasandstone being the dominant rock type. In the basal parts of the formation abundant silt is present, and this is very evident where differential erosion of the thin grey metasandstones and darker grey metasiltstones has produced thinly ribbed or striped outcrops. Bioturbated intervals are present particularly in these lower silt intervals. Some small scale cross-bedding with sets up to 25 cm thick are noticeable in the more massive sandstones near the base of the formation. Here, too, thin metasiltstones up to 1 m thick break the monotony of the laminated metasandstones.

With the decrease in silt content, the laminated sandstones make bolder and more massive outcrops and appear much paler than the earlier described clastics due to the better sorting resulting in less fines and the consequent decrease in dark micas. Mica is still present but evenly dispersed, giving the weathered rocks a "salt and pepper" appearance. Although the rocks are still well laminated, cross-bedding becomes a prominent feature from about a third of the way through the formation. The sets are generally about 1 m or less in thickness, although 2 m thick sets were recorded. The sands fill low amplitude channels cut into the laminated beds and are themselves laminated. Small and large scale slumps have resulted from movement down the direction of the cross-bedding. The variability in direction of slump axes precludes any conclusions regarding a source direction for the sediment.

It is uncertain whether the flat laminations represent a very high energy regime, or were produced under shallow water and less energetic conditions. Whatever the answer, it seems clear that they represent rapid deposition because of the instability of the cross-bedded sets of laminated sands involved in the slumping, and also because of the absence of bioturbation in the same beds as compared with the high incidence of bioturbation seen in the lower portions of the formation. Presumably these were deposited under much less energetic conditions. It is possible that the formation could be subdivided into two members on the basis of its silt content and type of bedding, but we do not wish to do this at present.

On the overturned limb of the regional anticline between Campbell Creek and Madigan Inlet, the Carrickalinga Head Formation and in particular the Backstairs Passage Formation have been greatly attenuated by shearing and faulting. This is especially so for the latter, which has been all but eliminated on the coastline. A fault, although not observed, is shown on our map to take account of the missing interval.

It is probable that the Backstairs Passage Formation and the Stokes Bay Sandstone of northern Kangaroo Island are synonymous. However, further work needs to be carried out on the Stokes Bay Sandstone before any finality can be attained. Until an adequate comparison can be made we will continue to employ the Backstairs Passage Formation as a workable stratigraphic unit.

(iii) *Talisker Calc-siltstone (phyllite phase)*

This newly named formation is the most characteristic member of the Kanmantoo Group so far encountered in our traverse along the south coast. The formation is unfossiliferous. Its contact with the adjacent formations is sharp. The calc-phyllites are strongly banded and predominantly light and dark grey in colour. The lighter bands are generally more calcareous. In places the lighter bands are coarse grained marbles, occurring as thin, discontinuous stringers within the formation due to the strong deformation within the area. Minor folds are ubiquitous. Sulphide-rich zones are evident from the rusty colouring on the exterior of the phyllites.

On the overturned limb of the regional anticline, the formation appears to occupy about twice the width of outcrop as on the eastern limb. In fact it is better examined there because of its easy accessibility. A dry weather track, suitable only for four-wheel drive vehicles, passes to the west of the Talisker Mine and is readily negotiated as far as Campbell Creek. From this point the calc-phyllites occur eastward for nearly 1 km. Again they are characteristically banded, and differential weathering in places gives the rock a ribbed appearance. Segregations of quartz-chlorite-muscovite pegmatite are prominent as on the normal limb of the regional anticline. Perhaps the most conspicuous feature of the overturned limb is the intensity of the small scale folding so beautifully expressed in the cliff faces. Near

Campbell Creek, southerly plunges are common, but further east the plunges are towards the north-east at varying angles, generally shallow. Mineral streaking on bedding planes is directed towards the south-east between N110° to N150°. Sulphide-rich (predominantly pyrrhotite) bands of calc-phyllites are common, particularly near the basal and middle parts of the formation. One sulphide band about 10 m thick lies immediately east of a 60 cm thick quartzite, and is conspicuous from the oxidation colours on the phyllites. Cleavage within the band is commonly enhanced by the presence of sulphides and their oxidation products. Other similar sulphide-rich bands occur in the formation to the east but are not shown on Fig. 2. Indeed, the whole sequence contains varying amounts of sulphides, and the zones are so numerous that it is impracticable to plot them on the scale of our map.

A strongly boudinaged amphibolite dyke cuts the formation, and is visible on the coastline in about the middle of the formation on the eastern limb of the regional anticline.

(iv) *Tapanappa Formation*[7]

On the normal limb of the regional anticline, an enormously thick and extremely monotonous sequence of dark coloured and dirty metasandstones with thin grey phyllite interbeds rests conformably on the Talisker Calc-siltstone. In general aspect, the formation recalls the basal member of the Carrickalinga Head Formation, in that the metasandstones are are split by thin phyllites, and in limited exposures could be confused with it. The metasandstones include fine grained to coarse grained varieties, the latter being the commoner, and in these there is obvious biotite and feldspar. Internally the sandstone beds, generally of the order of less than 1 m and rarely more than 2 m in thickness, are poorly bedded to well bedded. Cross-bedding is common, and in some intervals large scour channels filled with cross-bedded sands are obvious, for example between Porpoise Head and Deep Creek. Flat bedded and small scale current bedded sandstones are also present. Actinolite-garnet nodules are again common within the metasandstones, but they do occur in some of the metasiltstone to phyllite interbeds.

In some parts of the formation the metasandstones are highly cleaved, no doubt due to large amounts of fines in the original sediment, which have recrystallised to micas. The only fossils found within the formation were *worm-casts* in metasandstones interbedded with metasiltstones in the vicinity of Porpoise Head.

The phyllites are generally grey to dark grey in colour, and tend to weather olive-green away from the coast. They vary in thickness from mere partings to beds up to 10 m thick, but the latter are exceptional. They are commonly less than 0.5 m thick. Overall, there seems to be more phyllite present from Tunkalilla Beach eastwards. The phyllites occasionally are well-bedded, and in some localities, for example east of Deep Creek and in the old coastal cliffs inland from Tunkalilla Beach, porphyroblasts of micas and chlorite are randomly oriented within the rocks.

The only other rock type present is conglomerate. This first appears in the sequence in the cliffs just west of Aaron Creek. Similar thin bands occur sporadically and higher in the formation, but assume more importance as Tunkalilla Beach is approached. The conglomerates appear to be lenticular, and are generally less than 2 m thick. They are cut-and-fill into the underlying sediments, and are frequently cross-bedded and contain pebbles of quartz (including blue opalescent quartz), feldspar, quartzite, gneisses, rare phyllites, and limestones and dolomites. The carbonate pebbles (marbles) are always present and make up a significant proportion of some bands. The maximum pebble size seen was approximately 8 cm in diameter. The significance of the conglomerates is discussed below.

Two significant sulphide-rich bands were located within the Tapanappa Formation during our traverse, and these are shown on Fig. 2. Both are approximately 2.5 m thick, and consist of calcareous laminated phyllites interbedded with thin metasiltstone beds up to 8 cm thick. The phyllites show small scale current-bedding. The sulphide is fine grained and evenly disseminated through the phyllites and metasiltstones, and is shown by petrographic

[7]The formation has been named after the geographic feature called Tapanappa Hill. On the Barker 1:250,000 sheet, the Inman Hill Formation (Forbes 1957) as shown on the south coast of Fleurieu Peninsula includes the metasediments we have mapped as Backstairs Passage Formation, Talisker Calc-siltstone, and Tapanappa Formation. As we are uncertain that the beds herein termed Tapanappa Formation are the same as included in the type Inman Hill Formation, we prefer to use the former term. (See also Table 2.)

examination to be dominantly pyrrhotite. One unusual feature of the sulphide band near Porpoise Head is the presence of abundant fine grained sphene. This is absent from the band to the east of Boat Harbour Creek.

The finding of major sulphide-rich bands within the Tapanappa Formation, and in fact their occurrence throughout much of the basal part of the Kanmantoo Group as described herein, has interesting implications. This is especially important in view of the fact that the presence of sulphide bands within Kanmantoo Group metasedimentary rocks is a characteristic feature of the Nairne Pyrite Member, and it has been the tendency of earlier workers to map this Member on the basis of the sulphide-rich "marker beds". Clearly, the presence of sulphides is not a valid *single* criterion for the recognition of the Nairne Pyrite, and such use may lead to quite incorrect stratigraphic and structural interpretations of the geology in parts of the southern and eastern Mt. Lofty Ranges.

The position of the lower boundary of the Tapanappa Formation on Fig. 2 lies about 1 km further east than the boundary of the Inman Hill Formation on the Barker 1:250,000 sheet. It would appear that Thomson & Horwitz have included the Backstairs Passage Formation and the Talisker Calc-siltstone in what they have called the Inman Hill Formation. They are specifically excluded from the Tapanappa Formation as used herein because they are distinct units, capable of being recognised and mapped elsewhere, and their inclusion in the Tapanappa Formation would destroy the uniformity of that formation. For the purpose of this paper, we have tentatively located the upper boundary of the Tapanappa Formation on the normal limb of the regional anticline approximately 2.5 km west of Tunk Head. Here, in the cliffs inland from Tunkalilla Beach, the Tapanappa Formation is overlain conformably by a 10 m thick band of dark coloured and laminated phyllite, followed above by a sequence of fine grained to coarse grained metasandstones with thick phyllite interbeds. On the overturned western limb of the regional anticline, we interpret the Talisker Fault (Jervis 1:63,360 sheet), along the coastline just west of Campbell Creek, as a conformable boundary between the Talisker Calc-siltstone and the stratigraphically younger Tapanappa Formation.

As seen from Fig. 2, the Tapanappa Formation is mainly east-facing, except where folds intervene. Fold plunges are shallow, with axes directed towards the north-east or south-west. In this regard they mimic the axial direction of the regional anticlinal closure at Madigan Inlet. We have been unable to locate major faulting within the formation. However, shearing is associated with the folding but is apparently not significant on a macro scale.

STRUCTURE

Our observations to date mainly apply to the eastern limb of a regional anticlinal structure, in which the western limb is overturned and shows evidence for considerable tectonic thinning. All mesoscale folds so far observed conform to the style of the regional structure. They are inclined and asymmetric, with east limbs of anticlines longer than west limbs, and an axial plane cleavage dipping steeply towards the south-east. In many cases, dislocation of the overturned west limbs of mesoscale anticlines and the east limbs of mesoscale synclines has taken place along thrust zones which nearly parallel the axial plane cleavage. As described, these folds correspond to the F_1 folds of Offler & Fleming (1968).

A π-diagram, plotted from measured bedding attitudes, shows the overall fold axis to be plunging at a very shallow angle towards approximately N45°. However, mesoscale fold axes are spread along a great circle. This spread is substantiated from measurements of long axes of phosphate nodules in the Heatherdale Shale, and actinolite-garnet rods in the Carrickalinga Head Formation and the Tapanappa Formation, and is interpreted as indicating refolding of F_1 folds by a second deformation. Bedding plane lineations in the Forktree Limestone and the Talisker Calc-siltstone, due to the elongation of calcite crystals and sulphide mineral grains respectively, plunge towards approximately N115° at about 65° and may correspond to the fold axis of the second generation folds. The bedding plane lineations are the only evidence so far observed for second generation structures. We have seen similar relationships in adjacent areas including the Encounter Bay area and Dudley Peninsula, Kangaroo Island. However, the further definition and understanding of these overprinting relationships will be dependent on the extension of our present traverse along the south coast of Fleurieu Peninsula.

Considerable tectonic thinning of formations has occurred on the western limb of the regional anticline. For example, as discussed above, much of the Heatherdale Shale, the upper two members of the Carrickalinga Head Formation, and all but the uppermost few metres of the Backstairs Passage Formation are missing from this section. We prefer to ascribe the absence of much of the Carrickalinga Head Formation and the stratigraphically younger Backstairs Passage Formation as the result of faulting, but we were unable to find such a fault. Consequently, a tentative fault has been drawn in the appropriate place on Fig. 2 to account for the missing interval. We believe it probable that the Heatherdale Shale has been thinned as a result of thrusting along cleavage planes, which are closely spaced and dipping at a shallower angle than the bedding, although faulting within the formation must remain a possibility.

We wish to make quite clear that any thicknesses of formations and members computed from Fig. 2 can have no meaning because of the ubiquitous small scale folding. In all but the most competent formations and members, the folds are generally not of sufficiently large scale to show on our map. The incompetent carbonate-rich formations and the fine grained phyllite and metasiltstone members of the Carrickalinga Head Formation particularly, are complexly folded on a small scale, with folds varying in amplitude from several centimetres up to several metres.

METAMORPHISM

Offler & Fleming (1968) have assigned the metasedimentary rocks along the southern coastline of Fleurieu Peninsula to the biotite zone of metamorphism, passing eastwards into the higher grade andalusite-staurolite zone. The lower boundary of their andalusite-staurolite zone intersects the coastline at about the position of the regional anticlinal axis at Madigan Inlet, and has been defined by the "incoming of andesine or andesine + epidote in calc-schists and calc-silicate rocks". However, they stress that the boundary is only approximately located on parts of Fleurieu Peninsula, including the southern coastline, "because of the lack of suitable rock types".

Our investigations have shown that the following mineral assemblages occur in the metasedimentary rocks between Campbell Creek and Tunkalilla Beach:

(a) in calc-silicate rocks—
andesine, ± calcite, actinolite, garnet, ± chlorite, + epidote, ± biotite;

(b) in calc-phyllites and calcareous metasiltstones—
andesine, ± muscovite, biotite, calcite, ± actinolite, ± garnet, ± chlorite;

(c) in phyllites and metasiltstones—
andesine, biotite, chlorite;

(d) in impure metasandstones—
andesine, chess-albite, biotite, ± garnet, ± epidote, muscovite.

Quartz is ubiquitous in all assemblages. We have not observed staurolite, andalusite or cordierite, nor have we seen the andalusite-type knots consisting of quartz, muscovite, chlorite, ± albite described by Offler & Fleming (1968) as preceding the first appearance of andalusite in pelitic schists elsewhere in the Mt. Lofty Ranges. Thus we are not able to locate the lower boundary of the andalusite-staurolite zones as defined by the staurolite or andalusite isograds. However, on the basis of the coexistence of plagioclase with calcite, epidote, and actinolite, and because of the stability of the assemblage quartz + chlorite, it is possible to locate the grade of metamorphism at the top of the low-stage (as defined by Winkler 1970) between the almandine garnet isograd and the staurolite isograd.

Discussion and Conclusions

As a result of our study of the Kanmantoo Group in its type area, several facts emerge from which a number of conclusions can be drawn.

(a) *Stratigraphic Relationships*

On Fleurieu Peninsula, the Kanmantoo Group rests conformably and with sharp contact on the Heatherdale Shale. Moreover, in the same region, there is no evidence for either unconformity or disconformity at its base, as proposed initially by Campana & Horwitz (1956) and most recently by Thomson *in* Parkin (1969). In all areas where Kanmantoo Group rocks rest on rocks older than the Heatherdale Shale, faulting can be shown to explain the situation, as for example south-east of Yankalilla Hill. Similar fault relationships are believed to exist through much of the eastern Mt. Lofty Ranges, where the unconformity concept has been applied by many geologists to explain relationships first interpreted by Sprigg, Whittle & Campana (1951) as due to faulting.

(b) *The Kangarooian Movements and Kanmantoo Group Sedimentation*

The clear-cut contact between the Heatherdale Shale and Kanmantoo Group indicates the suddenness with which the new type of sediments became available and were brought into the basin of deposition. They were essentially non-calcareous and in contrast to the earlier deposited Cambrian sediments. The new sediments were mainly unsorted sands and silts eroded from newly emergent land masses uplifted in response to movements in the present Investigator Strait and Gulf St. Vincent[s]. Other areas involved were the Gawler Nucleus and its southerly prolongation onto and perhaps even beyond the present continental shelf. Such Lower Cambrian movements, both positive (for source areas) and negative (for depositional areas) and their connection with Kanmantoo Group sedimentation were first alluded to by Sprigg (1955) and later documented by Daily (1956, pp. 99–100, 125–128, 138–140), Campana (*in* Glaessner & Parkin 1958, pp. 17–18), Horwitz & Daily (*in* Glaessner & Parkin 1958, p. 55), Daily (1963, p. 596; 1969, p. 52) and elsewhere[8]. Daily & Forbes (1969) named these movements the Kangarooian Movements (after the locality Kangaroo Island, along the north coast of which their effects are best recorded) in preference to the term "orogeny" as initially suggested in 1956. Thomson (*in* Parkin 1969, p. 99; 1970, p. 215) has used the terms Cassinian Uplift and Waitpingan Subsidence to account for the same movements; however, it is proposed here that the term Kangarooian Movements is more appropriate because it retains the spirit of the concept as used in Daily (1956).

In addition, the movements as recorded on both Kangaroo Island and Yorke Peninsula were multiple in character. Moreover, the instability in the latter region, as shown in the sedimentary record, extended from the Lower Cambrian into the Middle Cambrian. Periods of quiescence punctuated the positive phases of the movements, and at these times limestones were deposited.

On Fleurieu Peninsula, the Kanmantoo Group metasediments reflect an almost continuous supply of clastics from the nearby tectonic lands. The sands are impure and poorly sorted, and on the whole indicate rapid deposition in a rapidly subsiding basin. However, deposition was not rapid enough to prevent organisms from reworking the newly laid sands, as in parts of the Carrickalinga Head Formation and Backstairs Passage Formation. The Talisker Calc-siltstone is an exception in that there is a general fall off in the supply of coarse clastics at the time of its deposition, but it would seem that negative movements within the basin were such that the depositional interface was brought to depths where stagnant bottom conditions favoured the deposition of abundant sulphides.

The Tapanappa Formation contains many lenses of small scale conglomerates. Rock fragments are commonly angular, and hence show evidence of little transport. Many pebbles are of older Precambrian gneisses and other crystalline rocks, and the high incidence of marbles, by analogy with Kangaroo Island and Yorke Peninsula, presumably represent the stripping of Lower Cambrian limestones and dolomites, and the underlying crystalline basement, from nearby rising fault blocks. The high feldspar content of metasandstones within the Kanmantoo Group is an indication of the strong role played by the crystalline basement in supplying much of the sediment.

(c) *The New Stratigraphic Scheme for the lower part of the Kanmantoo Group*

The stratigraphic scheme as given in Table 1 will form the basis for our future investigations elsewhere within the area of distribution of the Kanmantoo Group. We regard the Talisker Calc-siltstone as a marker bed, and wish to

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[8]Several unpublished reports by one of us (B.D.) and held on open file by the South Australian Mines Department, have developed this theme, especially for the Yorke Peninsula Region.

(a) Daily, B. (1957).—Progress report on the Cambrian sequence met with in the Minlaton Stratigraphic Bore 1, Section 153, Hd. Ramsay, Yorke Peninsula, South Australia. Unpublished report to S.A. Mines Department.

(b) Daily, B. (1967).—Stansbury West No. 1 and Edithburgh No. 1 Wells—Subsurface Stratigraphy and Palaeontology of the Cambrian Sequence. Unpublished report to Beach Petroleum N.L.

(c) Daily, B. (1968).—Stansbury Town No. 1 Well—Subsurface Stratigraphy and Palaeontology of the Cambrian Sequence. Unpublished report to Beach Petroleum N.L.

As mentioned in (c), a discussion of a correlation chart for all wells mentioned in (a), (b) and (c) was presented to the South Australian Division of the Geological Society of Australia, July 27, 1967.

TABLE 1

Stratigraphic scheme for the lower part of the Kanmantoo Group in its type section

	Formation	Member
Kanmantoo Group	Tapanappa Formation	
Kanmantoo Group	Talisker Calc-Siltstone	
Kanmantoo Group	Backstairs Passage Formation	
Kanmantoo Group	Carrickalinga Head Formation	Campana Creek Member
Kanmantoo Group	Carrickalinga Head Formation	Blowhole Creek Siltstone Member
Kanmantoo Group	Carrickalinga Head Formation	Madigan Inlet Member
	Heatherdale Shale	Upper member (unnamed)
	Heatherdale Shale	Lower member (unnamed)
	Forktree Limestone	Upper member (unnamed)

point out that we have recognised it recently on both limbs of an overturned anticline on Kangaroo Island. It is imperative that a search be made inland on Fleurieu Peninsula for these calc-phyllites, particularly in the type section of the Inman Hill Formation (Forbes 1957) as well as further north.

As shown in Table 2, three stratigraphic schemes have been applied to the type section of the Kanmantoo Group. We reject the lowest two units in the Thomson & Horwitz scheme for the reasons stated above, but can not comment on the Brukunga Formation as this interval is still to be investigated by us. With regard to the two other schemes, it is important to note that the formation boundaries mapped both by Dr. R. J. George (see footnote 4) and us on the normal limb of the regional anticline are practically coincident. We differ from George essentially in the choice of names for the formations recognised. George chose his nomenclature because he was impressed by the occurrence of sulphides in the Talisker Calc-siltstone, and because it lay stratigraphically above a cross-bedded, slumped arkosic formation, and below a greywacke sequence. These three formations he equated with the Nairne Pyrite, the Inman Hill Formation, and the Brown Hill Greywacke respectively. There would be considerable merit in this action but for the fact that on the Barker 1:250,000 sheet, the Brukunga Formation is mapped along the south coast of Fleurieu Peninsula as commencing nearly 16 km to the east of the upper limit of the Talisker Calc-siltstone. We cannot ignore the possibility that George is correct in equating the Talisker Calc-siltstone with the Nairne Pyrite, which incidentally does contain calcareous metasedimentary rocks. If this suggestion is correct, then the geology of the Kanmantoo Group on the Barker 1:250,000 sheet is in need of much greater revision than we presently propose.

TABLE 2

Schemes of Stratigraphic Nomenclature utilised in the type section of the Kanmantoo Group between Campbell Creek and Rosetta Head

		Thomson & Horwitz (1962) Thomson *in* Parkin (1969)	George (unpublished)	Daily & Milnes (this paper)
KANMANTOO GROUP	Brukunga Formation	Brown Hill Greywacke Member*	Not investigated	Not yet investigated
KANMANTOO GROUP	Brukunga Formation	Nairne Pyrite Member		
KANMANTOO GROUP		Inman Hill Formation	Greywacke of Brown Hill	Tapanappa Formation
			Nairne Pyrite Equivalent	Talisker Calc-siltstone
			Inman Hill Formation	Backstairs Passage Formation
KANMANTOO GROUP		Strangway Hill Formation†	Carrickalinga Head Formation	Carrickalinga Head Formation

* Thomson & Horwitz (1962) have not mapped this member along the coastline within the type section.

† The term Strangway Hill Formation was not used in the legend of the Barker 1:250,000 sheet (Thomson & Horwitz 1962) for the rocks exposed along the coastline between Campbell Creek and the base of the Inman Hill Formation. However, the Strangway Hill Formation is shown in Fig. 44 in Thomson *in* Parkin (1969), as occupying this interval of coastline. In fact, as seen from our Fig. 2 the same coastal section contains rocks within the regional anticline ranging from Forktree Limestone to the Talisker Calc-siltstone.

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EXPLANATION OF FIGURES

Fig. 3. Anticlinal closure in mottled marbles of the Forktree Limestone forming the core of the north-easterly plunging regional anticline, east side of Madigan Inlet.

Fig. 4. Deformed mottled marbles on the overturned limb of the regional anticline, east side of Madigan Inlet. View looking towards N200°. Coin 2.3 cm in diameter.

Fig. 5. Flaggy outcrops of marbles with thin phyllitic partings, near top of upper member of the Heatherdale Shale, east limb of regional anticline, small bay just east of Madigan Inlet.

Fig. 6. Deformed ovoid limestone concretions in upper member of Heatherdale Shale, immediately east of Fig. 5. Hammer length 28 cm.

Fig. 7. Aligned black phosphatic nodules in dark coloured phyllites on overturned limb of Heatherdale Shale, creek exposure at Madigan Inlet. Coin 2.8 cm in diameter.

Fig. 8. View looking south showing the extremely attenuated Heatherdale Shale on the overturned limb of the regional anticline, Madigan Inlet. From left to right—Marbles of Forktree Limestone on point, phyllites of Heatherdale Shale forming bay and in creek exposure in right foreground, and metasandstones and phyllites of Carrickalinga Head Formation on coast. Figure 1.3 m tall.

Fig. 9. Contact between light coloured basal beds of the Kanmantoo Group and the black sulphide-rich phyllites of the underlying Heatherdale Shale, cove just east of Madigan Inlet. View looking south.

Fig. 10. Hammer on contact between Heatherdale Shale and basal phyllite of the Kanmantoo Group. Note elongated dark coloured actinolite-garnet nodule in metasandstone about 35 cm to right of hammer.

Fig. 11. Deformed bedding in interbedded metasandstones and metasiltstones near base of Campana Creek Member of the Carrickalinga Head Formation, just east of Campana Creek. Hammer handle lies parallel to cleavage.

Fig. 12. Bioturbated beds near base of Campana Creek Member of Carrickalinga Head Formation, same locality as Fig. 11. Pen is 14 cm long.

Fig. 13. Well laminated metasandstones, lower portion of the Backstairs Passage Formation, 0.5 km south-east of Blowhole Creek. Lens cap 7 cm in diameter.

Fig. 14. Laminated (top) and slumped (bottom) metasandstones of the Backstairs Passage Formation, 1 km south-east of Blowhole Creek.

Fig. 15. Banding in dark and light grey (calcareous) phyllites of the Talisker Calc-siltstone on the overturned limb of the regional anticline, just east of Campbell Creek. Note pegmatitic segregations of quartz and chlorite (also light coloured).

Fig. 16. Parasitic folds (plunging towards N50°) in Talisker Calc-siltstone on the overturned limb of the regional anticline, about 0.5 km south-east of Campbell Creek. Note short overturned limbs and long normal limbs of folds, and shearing of overturned limbs.

Fig. 17. Band of small scale conglomerate with overlying laminated metasandstone in Tapanappa Formation, just west of Tunkalilla Beach.

Fig. 18. Large partly rounded pebbles of quartzites and gneiss in small scale conglomerate, same locality as Fig. 17. Maximum diameter of pebble (upper right) is 7 cm.

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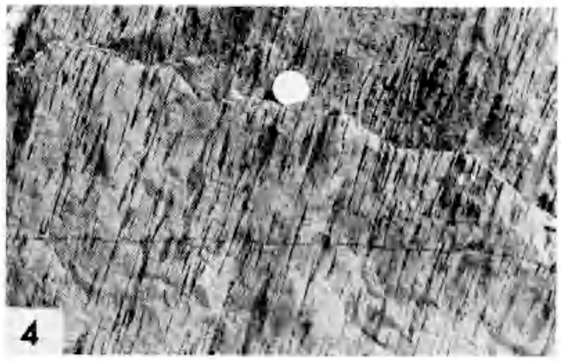
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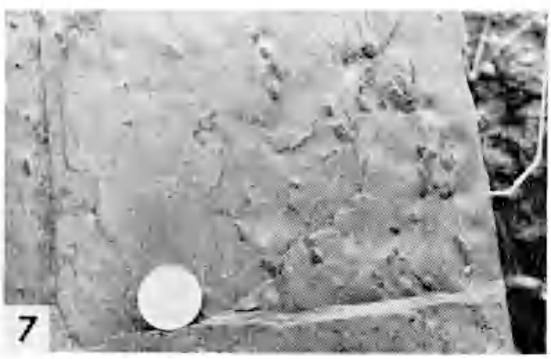
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